NISAR L-Band and S-Band Instrument Antennas: Compatibility Test and Results

Paolo Focardi[1], Joseph D. Vacchione[1], Jefferson A. Harrell[1]
[1] Jet Propulsion Laboratory, California Institute of Technology, Spacecraft Antennas Group, Pasadena, CA, USA,
paolo.focardi@jpl.nasa.gov

***Abstract*—NASA ISRO SAR (NISAR) is one of the next major Earth science flight projects that NASA is currently developing in collaboration with ISRO, the Indian Space Research Organization. Featuring a 12m deployable off-set reflector, similar to SMAP but twice as large, and a dual band, dual polarization feed array, NISAR will measure with great accuracy even the smallest changes on our planet's landmass, ice-sheet and forests over a 3 year period with a 12-day repeat cycle everywhere on the globe. Two radar systems will be sharing the same reflector, one operating in L-Band and one in S-Band. While the L-Band radar and feed antenna are being developed at Jet Propulsion Laboratory (JPL) for NASA, the S-Band feed antenna is under development at the Space Application Centre (SAC) in Ahmedabad, India, for ISRO. This paper describes the tests that were carried out both at JPL and SAC in order to verify that the level of compatibility between the two feed antennas were within the allocated requirements. Both S-parameters and radiation patterns were measured and compared with calculated predictions.**

***Index Terms*—Reflector antennas, feed array, measurements, dual polarized antennas, dual frequency antennas, radar, Earth Science.**

I. INTRODUCTION

The NISAR L-Band feed antenna is a 12 element patch array where each element is a 2x1 subarray, or patch pair. The feed is organized in tiles, with each tile including 2 array elements, for a total of 6 tiles. Each array element is capable of radiating horizontal or vertical polarization independently and can also be operated in circular polarization. For a better description of the single tile please see [1]. The S-Band feed antenna is organized in a similar fashion but includes twice as many elements compared to the L-Band antenna, for a total of 24 elements divided in 3 tiles. Fig. 1 shows a view of the NISAR instrument with all its major components. Since the two antennas are being developed by two different organizations, NASA and ISRO agreed to run a compatibility test at the Engineering Model (EM) level to make sure the two antennas didn't interfere with each other. Moreover, while JPL was able to simulate the performance of the L-Band antenna including the presence of the S-Band antenna next to it, the complementary simulation at S-Band frequency was not feasible because of memory constraints. Therefore, this test was designed to remove any further risk of interference, especially at S-Band frequency.

JPL designed and fabricated a Ground Support Equipment (GSE) in order to simulate the actual underlying supporting structure in the Integrated Radar Instrument Structure (IRIS). The performance of the L-Band array was first measured at JPL with a mock-up in place of the S-Band antenna. Then the entire antenna was shipped to India for a combined test with the actual S-Band antenna. Once there, the L-Band antenna was measured again, first with the S-Band mock-up and then with the actual S-Band antenna mounted on the GSE. In both occasions, the performance of the L-Band antenna was compared with calculated predictions and a very good agreement was found in both cases.

Fig. 1, View of the deployed NISAR instrument. The L-Band and S-Band feed antenna arrays are located on the top deck of the IRIS.

II. JPL TESTS

The performance of each L-Band tile was first measured at JPL in a spherical near-field range both in terms of S-parameters and radiation pattern. Then, the complete EM L-Band array was mounted on the GSE and the performance was measured in the array configuration in a planar near field antenna range. For this operation, the S-Band antenna was replaced with a mock-up consisting of a simple folded aluminum layer to represent the S-Band ground plane at the correct height compared to the L-Band antenna. Both S-parameters and radiation patterns were also measured in the array configuration. Since the antenna will be used both in transmission (TX) and in reception (RX), a discrete feeding network made of coaxial phase-matched cables and power dividers was used to simulate the proper phasing of the array in TX mode. In fact, during transmit, the full array is fed with a small linear phase ramp across the aperture to steer the beam by about 5 degrees. During receive instead, the instrument is operated in sweep-SAR mode, where each receiving element is activated one at the time sweeping the entire array and the swath at the same time. The correct alignment of the antenna with the antenna range was verified by laser tracker metrology.

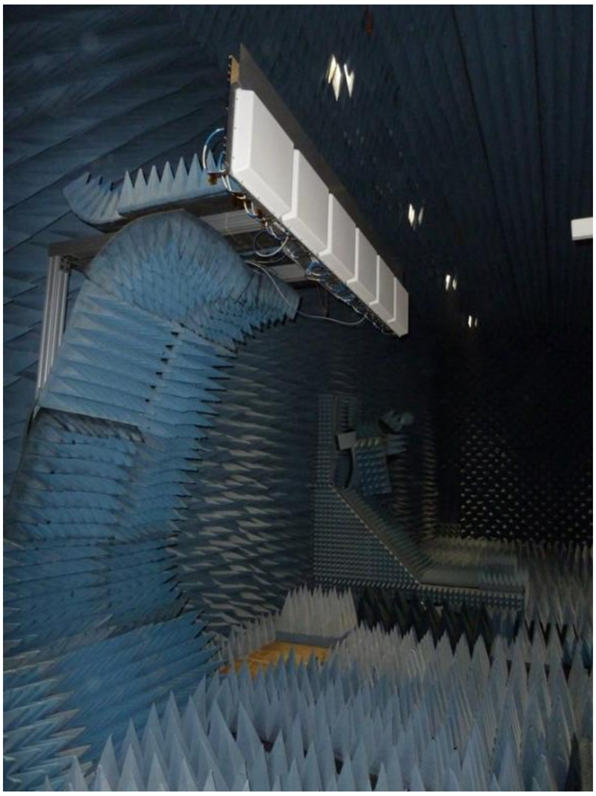

Fig. 2, L-Band feed array being tested at JPL. Note the S-Band mock-up above the six L-Band tiles.

III. SAC Tests

After the tests at JPL, the entire array plus two spare tiles were shipped to SAC, in India, for further testing. Once there, the array was assembled again and the S-parameters were tested in the same configuration that was used at JPL in order to verify that no damage had occurred during shipping, including the S-Band mock-up. Then the L-Band antenna was mounted on the SAC planar range and tested, including metrology by laser trackers. This test was also useful to understand how the planar range at SAC performed compared to the one at JPL. Once that was complete, the S-Band mock-up was replaced with the actual S-Band EM tiles. Once they were in place, a full set of S-parameters, including cross-band coupling, was measured in the anechoic chamber. Then the L-Band antenna was mounted in the planar range again and tested with the S-Band tiles. This concluded the L-Band part of the test. SAC personnel then measured the performance of the S-Band antenna with the presence of the L-Band one.

IV. Results

The tests that were done both at JPL and at SAC managed to confirm with very good accuracy and consistency the performance of the L-Band antenna compared to the calculated S-parameters and radiation patterns. A very good agreement was found first with the single tile measurements at JPL. The array measurements also confirmed the changes in performance expected by the single tiles in the array environment. The tests at SAC, confirmed once again the performance and also verified the quality of the antenna ranges of both institutions by producing results almost indistinguishable from those measured at JPL.

Fig. 3, Group photo at SAC in Ahmedabad.

Radiation pattern measurements and calculations were carried out at 3 L-Band frequencies, on 3 different tiles in RX mode and over the full array in TX mode. Data was compared over 4 major cuts, for Phi = 0°, 45°, 90° and 135°, where Phi = 0° is aligned with the length of the array and Phi = 90° is cutting across the array. Both Co-polar and Cx-polar components at both horizontal and vertical polarization were compared. Fig. 4 shows the co-polar component of the horizontal polarization from the first element of the array at 1.2575 GHz and for Phi = 0°. As can be seen from the figure, The measured L-Band data at SAC with the S-Band mock-up (blue) and the data with the actual S-Band antenna (red) compares very well with the calculated pattern (green). In particular, the asymmetrical mutual coupling of the first element of the array is quite visible in this cut and manifests itself with a clear asymmetry in the pattern. Fig. 5 shows the same set of data for the cross-polar component of the horizontal polarization, still from the first element of the array. Again, the agreement is quite good, considering the low level of the cx-pol. Fig. 6 shows an example of the co-polar component of the vertical polarization from the same element but this time on a cut for Phi = 90°. In this case the pattern appears almost perfectly symmetrical as expected. Moreover the agreement between the three data sets is quite remarkable. Fig. 7 shows the results for the cx-polar component for the same vertical polarization case.

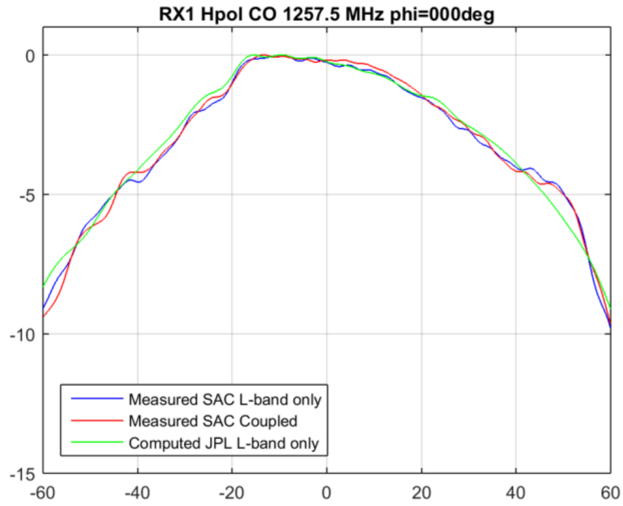

Fig. 4, Measured and calculated normalized pattern of the co-polar component, in dB over Theta angle, of the horizontal polarization at 1.2575 GHz for Phi = 0°, from element 1 of the array.

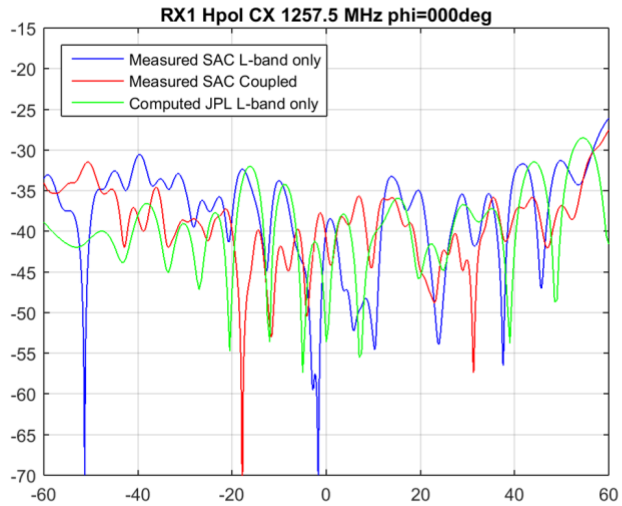

Fig. 5, Measured and calculated normalized pattern of the cx-polar component, in dB over Theta angle, of the horizontal polarization at 1.2575 GHz for Phi = 0°, from element 1 of the array.

Also in Fig. 7, the null for Theta = 0° is clearly shown by both the calculated and measured data, demonstrating at the same time the good quality of the antenna and a good alignment between the antenna and the antenna range. Other examples of measured and calculated data for both radiation patterns and S-parameters are also available and will be shown at the conference for various antenna tiles along the array and for the array in TX mode.

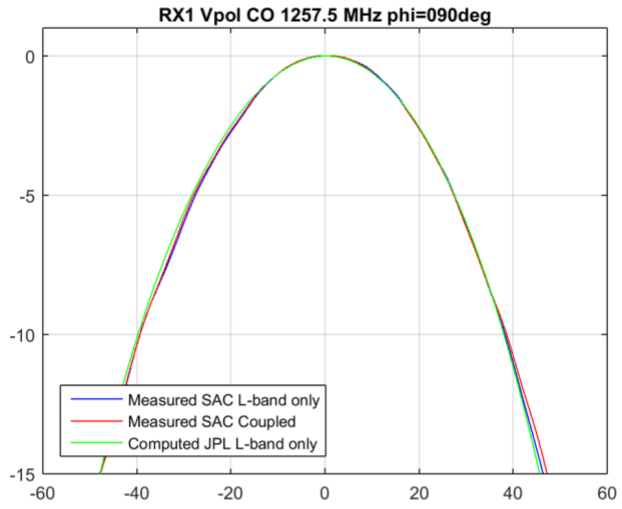

Fig. 6, Measured and calculated normalized pattern of the co-polar component, in dB over Theta angle, of the vertical polarization at 1.2575 GHz for Phi = 90°, from element 1 of the array.

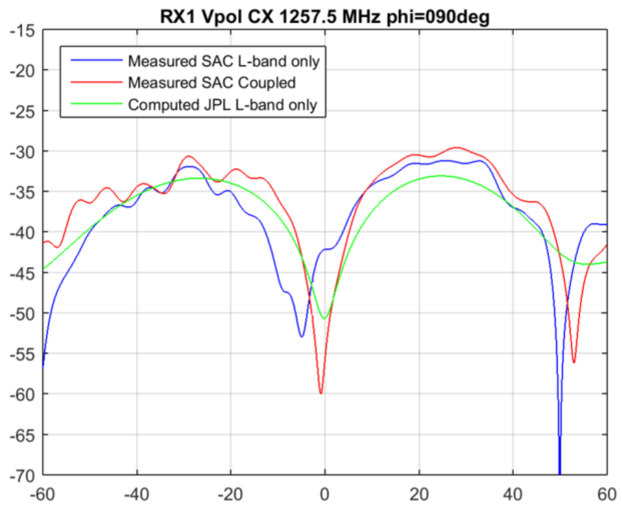

Fig. 7, Measured and calculated normalized pattern of the cx-polar component, in dB over Theta angle, of the horizontal polarization at 1.2575 GHz for Phi = 90°, from element 1 of the array.

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